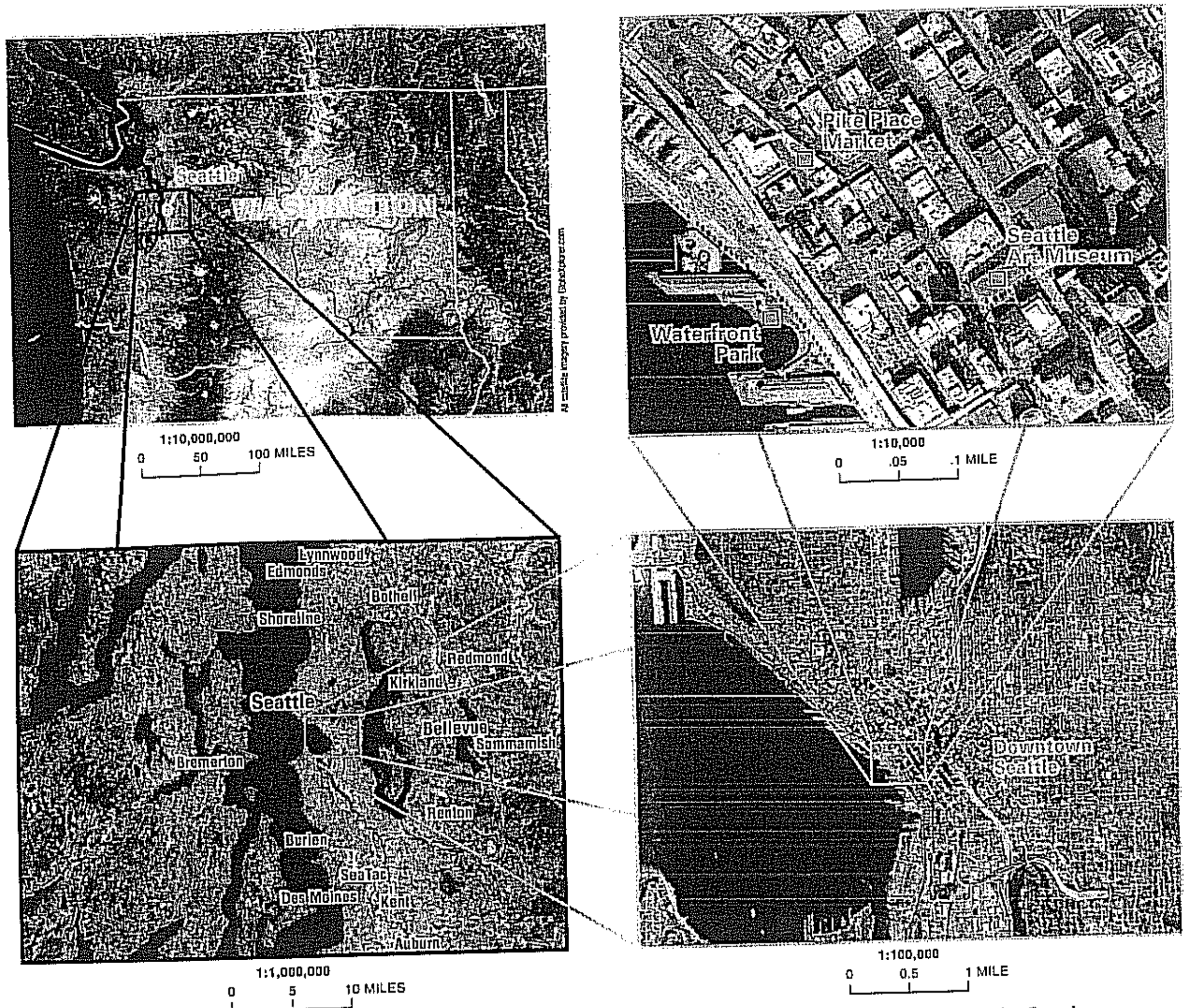

FIGURE 1–3 Map scale. The four images show Washington State (upper left), Western Washington (lower left), the Seattle region (lower right), and downtown Seattle (upper right). The map of Washington State has a fractional scale of 1:10,000,000. Expressed as a written statement, 1 inch on the map represents 10 million inches (about 158 miles) on the ground. Look what happens to the scale on the other three maps. As the area covered gets smaller, the maps get more detailed, and 1 inch on the map represents smaller distances.

- The meridians (the vertical lines), which in reality converge at the North and South poles, do not converge at all on the map. Also, they do not form right angles with the parallels (the horizontal lines).

Two types of uninterrupted projections display information as shown in Figures 1–9 and 1–17 on pages 19 and 31. The Robinson projection, in Figure 1–17 on page 31, is useful for displaying information across the oceans. Its major disadvantage is that by allocating space to the oceans, the land areas are much smaller than on interrupted maps of the same size. The Mercator projection in Figure 1–9 on page 19 has several advantages: Shape is distorted very little, direction is consistent, and the map is rectangular. Its greatest disadvantage is that area is grossly distorted toward the poles, making high-latitude places look much larger than they actually are. For example, compare the sizes of Greenland and South America in the maps shown in Figures 1–2 and 1–9 on pages 6 and 19. The map in Figure 1–2 illustrates their size accurately.

Some of the other decisions that must be made when developing a map are presented in the Appendix.

U.S. Land Ordinance of 1785

In addition to the global system of latitude and longitude, othe mathematical indicators of locations are used in different part of the world. In the United States, the **Land Ordinance o 1785** divided much of the country into a system of township and ranges to facilitate the sale of land to settlers in the Wes The initial surveying was performed by Thomas Hutchin who was appointed geographer to the United States in 178 After Hutchins died in 1789, responsibility for surveying wa transferred to the Surveyor General.

In this system, a **township** is a square 6 miles on each sid Some of the north–south lines separating townships are calle **principal meridians,** and some east–west lines are designate **base lines** (Figure 1–4, upper left). Each township has a numb corresponding to its distance north or south of a particular ba

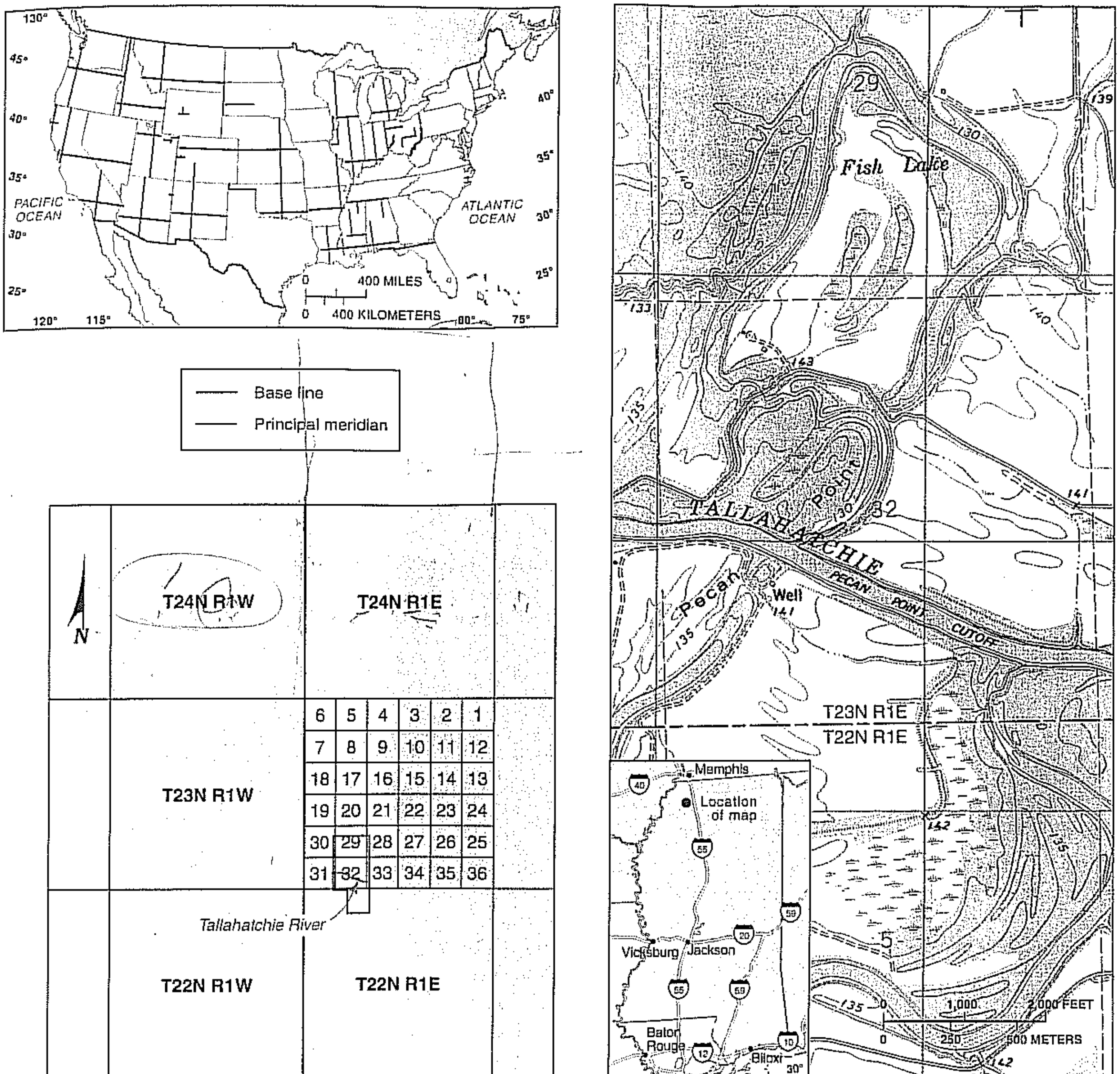

FIGURE 1–4 Township and range system. To facilitate the numbering of townships, the U.S. Land Ordinance of 1785 designated several north–south lines as principal meridians and several east–west lines as baselines (upper left). As territory farther west was settled, additional lines were delineated. Townships are typically 6 miles by 6 miles, although physical features, such as rivers and mountains, result in some irregularly shaped ones (lower left). The Tallahatchie River, for example, is located in the twenty-third township north of a baseline that runs east–west across Mississippi, and in the first range east of the principal meridian at 90° west longitude. Townships are divided into 36 sections, each 1 square mile. Sections are divided into four quarter-sections. The Tallahatchie River is located in the southeast and southwest quarter-sections of Section 32, T23N R1E. The topographic map (right), published by the U.S. Geological Survey, has a fractional scale of 1:24,000. Expressed as a written statement, 1 inch on the map represents 24,000 inches (2,000 feet) on the ground. The bar line below the map displays the scale in a third way. The map displays portions of two townships, shown on the above map. The brown lines on the map are contour lines that show the elevation of any location.

line. Townships in the first row north of a baseline are called T1N (Township 1 North), the second row to the north is T2N, the first row to the south is T1S, and so on. Each township has a second number, known as the *range*, corresponding to its location east or west of a principal meridian. Townships in the first column east of a principal meridian are designated R1E (Range 1 East). The Tallahatchie River, for example, is in township T23N R1E, north of a baseline that runs east–west across Mississippi and east of a principal meridian along 90° west longitude.

A township is divided into 36 **sections**, each of which is 1 mile by 1 mile (Figure 1–4, lower left). Sections are numbered in a consistent order, from 1 in the northeast to 36 in the

southeast. Each section is divided into four quarter-sections, designated as the northeast, northwest, southeast, and southwest quarters of a particular section. A quarter-section, which is 0.5 mile by 0.5 mile, or 160 acres, was the amount of land many Western pioneers bought as a homestead. The Tallahatchie River is located in the southeast and southwest quarter-sections of Section 32.

The township and range system remains important in understanding the location of objects across much of the United States. It explains the location of highways across the Midwest, farm fields in Iowa, and major streets in Chicago.

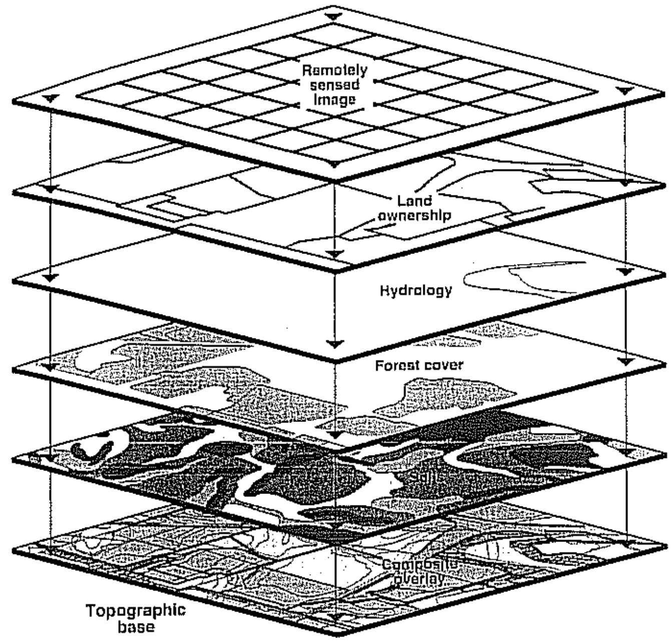

FIGURE 1–5 A geographic information system. GIS involves storing information about a location in layers. Each layer represents a different piece of human or environmental information. The layers can be viewed individually or in combination.

Contemporary Tools

Having largely completed the great task of accurately mapping Earth's surface, which required several centuries, geographers have turned to Geographic Information Science to learn more about the characteristics of places. Two important technologies that developed during the past quarter-century are remote sensing from satellites (to collect data) and geographic information systems (computer programs for manipulating geographic data). Geographic Information Science helps geographers to create more accurate and complex maps and to measure changes over time in the characteristics of places.

GIS

A **GIS (geographic information system)** is a computer system that can capture, store, query, analyze, and display geographic data. The key to GIS is geocoding: The position of any object on Earth can be measured and recorded with mathematical precision and then stored in a computer. A map can be created by asking the computer to retrieve a number of stored objects and combine them to form an image.

GIS can be used to produce maps (including those in this book) that are more accurate and attractive than those drawn by hand. In the past, when cartographers drew maps with pen and paper, a careless moment could result in an object being placed in the wrong location, and a slip of the hand could ruin hours of work. GIS is more efficient for making a map than pen and ink: objects can be added or removed, colors brightened or toned down, and mistakes corrected (as long as humans find them!) without having to tear up the paper and start from scratch.

Each type of information can be stored in a layer. For example, separate layers could be created for boundaries of countries, bodies of water, roads, and names of places. Depending on the desired purpose, a wide variety of maps can be created by turning on and off the various layers. A simple map might display only a single layer by itself, but most maps combine several layers (Figure 1–5), and GIS permits construction of much more complex maps than can be drawn by hand.

The value of GIS extends beyond the ability to make complex maps more easily. Layers can be compared to show relationships among different kinds of information. To understand the impact of farming practices on water pollution, a physical geographer may wish to compare a layer of vegetation with a layer of bodies of water. To protect hillsides from development, a human geographer may wish to compare a layer of recently built houses with a layer of steep slopes.

Scottish environmentalist Ian McHarg pioneered a technique of comparing layers of various physical and social features to determine where new roads and houses should be built and where the landscape should be protected from development. When McHarg was developing the technique during the 1960s—before the diffusion of powerful microcomputers and GIS software—he painstakingly created layers by laying hand-drawn plastic transparencies on top of each other. Four decades later, his pioneering technique can be replicated quickly on a desktop computer with GIS software.

GIS enables geographers to calculate whether relationships between objects on a map are significant or merely coincidental. For example, maps showing where cancer rates are relatively high and low (such as those in Figure 1–13) can be combined with layers showing the location of people with various incomes and ethnicities, the location of different types of factories, and the location of mountains and valleys (see Global Forces, Local Impacts box).

Remote Sensing

The acquisition of data about Earth's surface from a satellite orbiting Earth or from other long-distance methods is known as **remote sensing**. Remote-sensing satellites scan Earth's surface, much like a television camera scans an image in the thin lines you can see on a TV screen. Images are transmitted in digital form to a receiving station on Earth.

At any moment a satellite sensor records the image of a tiny area called a picture element or pixel. Scanners are detecting the radiation being reflected from that tiny area. A map created by remote sensing is essentially a grid containing many rows of pixels. The smallest feature on Earth's surface that can be